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Regular Article

Bidirectional associations between self-regulation and deviance from adolescence to adulthood

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Abstract

Self-regulation is considered a major predictor of crime and deviant behavior. However, longitudinal research investigating these associations, frequently looked only at the effect of self-regulation on deviant behavior, but not the other way around. The current study argued that deviance may contribute to later problems in self-regulation, and examined bidirectional associations, comparing a unidirectional and bidirectional model of associations between these variables. A Random Intercept Cross-Lagged Panel Model and eight data waves from 772 participants, aged 10–12 years to 30 years were used. Results showed that a bidirectional model fit the data better than a unidirectional model. The final model revealed an influence of deviance on self-regulation mainly in adolescence, whereas self-regulation influenced deviance only over two time points in adulthood. The results suggest that, in adolescence, problems in self-regulation may follow, rather than precede deviant behavior. Thus, decreasing deviant behavior or intervening in the aftermaths of deviant behavior in adolescence might have a positive effect on self-regulation in young adulthood, lowering the chance of adult deviant behavior. The current study shows that the long-presumed directionality of self-regulation to deviance can lead to bias, and more rigorous longitudinal research is needed in order to further inform theory and practice.

Keywords: bidirectional, deviance, longitudinal, self-regulation, RI-CLPM

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Introduction

Deviant behavior is characterized by extreme and less extreme norm- and rule-breaking behaviors (e.g., criminal behavior as well as lying and cheating) and can have considerable societal costs. Such costs not only include public safety and financial costs (Craig, Schumann, Petrunka, Khan, & Peters, 2011), but also extend to costs at the individual level for the person who commits a delinquent act. It follows that better conceptualizing the predictors of deviance is needed in order to reduce the deleterious effects associated with these behaviors. One factor that has been found to identify individuals who are at greater risk of showing persistent deviant behavior from adolescence into adulthood is poor self-regulation, or disinhibition (Raskin White, Bates, & Buyske, 2001). Self-regulation¹ can be defined as the typical ability

of a person to regulate his or her own thoughts, behavior, and emotions, in the service of reaching higher order goals, such as saving to buy a car instead of spending money on hobbies. Indeed, self-regulatory tendencies have been linked to many positive outcomes, including better grades, positive adjustment, and positive interpersonal relationships (Tangney, Baumeister, & Boone, 2004). In contrast, those who lack self-regulatory tendencies may have fewer positive outcomes, as they are more likely to engage in deviant or criminal behavior (see Vazsonyi, Mikuška, & Kelley, 2017). In the current study, we will investigate possible effects of self-regulation on deviance, as well as possible effects of deviance on self-regulation over time.

Several theories highlight the importance of self-regulation or related constructs in the development of deviant behavior. The General Theory of Crime (Gottfredson & Hirschi, 1990; Hirschi, 2004), states that low self-control, in combination with opportunity, would increase the likelihood of criminal and similar behavior. Furthermore, the authors put self-control forward as the only variable to explain all criminal type behavior. In addition, they argued that self-control remains stable and cannot be influenced by other factors after the age of 10 years. Other theories have been more nuanced in their approach, by looking at the influence of self-regulatory aspects in conjunction with other features. Agnew's General Strain Theory (Agnew, 1992; Agnew,

¹In the current study, we will use the term self-control as long as the conceptualization of the studies using the term self-control overlaps with or is nested in our broad definition of self-regulation.

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Brezina, Wright, & Cullen, 2002) implies that a combination of low self-constraint and negative emotionality, in situations of high personal strain (failure to achieve positively valued goals; removal of positive stimuli; introduction of negative stimuli), will lead to increased likelihood of offending. Agnew *et al.* (2002) indicated that strain can influence personality traits like constraint. Similarly, DeLisi and Vaughn (2014) in their Temperament-based Theory, proposed that an interaction between low effortful control and negative emotionality contributes to delinquent behavior. Although they did not specify at which age, Delisi and Vaughn do indicate that effortful control is changeable by intervention. Moffitt *et al.* (2011), having conducted large longitudinal studies on self-control, agreed on the influence of self-control on deviance, but also saw self-control as a skill that can be improved if trained. Although these researchers were not sure that interventions at later ages would be as effective as in earlier ages, they did find that adolescent mistakes influenced adult outcomes, and concluded that preventing these mistakes would improve outcomes in adulthood (Moffitt *et al.*, 2011). Although these authors did not make explicit predictions about the influence of deviance on self-regulation, in the cases of both Agnew *et al.* (2002) and Moffitt *et al.* (2011), a case could be made for the possibility that deviance can influence later self-regulation or later outcomes of self-regulation. That is, Agnew *et al.* indicated that strain can influence personality traits such as constraint, and deviant behavior might be seen as a strenuous activity. Likewise, Moffitt *et al.* claimed that mistakes made in adolescence (which could include deviant behaviors), can influence the same long-term outcomes as self-control.

Over the years, backed by these theories, many researchers have supported the expected association between self-regulation and crime or deviant behavior (see Vazsonyi *et al.*, 2017). However, most of the above-mentioned theories (*i.e.*, Agnew, 1992; DeLisi & Vaughn, 2014; Gottfredson & Hirschi, 1990) implicitly or explicitly assume that poor self-regulation is a precursor of (deviant) behavior, and do not explicitly consider potential bidirectional effects. As a result, past research, both cross-sectional and longitudinal, has predominantly considered this association from a unidirectional perspective without considering a bidirectional perspective. That is, assuming that self-regulation is an antecedent of deviance and not the other way around.

However, frameworks like the Risk Need Responsivity (RNR) model of Andrews and Bonta (2010) brought forward a more dynamic view of self-control. The RNR model indicates a lack of self-control (including weak constraint, impulsivity, lack of planning) as part of the Central Eight risk factors for offending behavior (*i.e.*, as part of an antisocial personality pattern). Unlike many theories, Andrews and Bonta (2010) view self-control as a dynamic criminogenic need; that is, a risk factor for deviant behavior (in this sense criminogenic) that is amenable to change (thus dynamic and reversible) and can therefore be a treatment target. Despite presenting a more dynamic view, the RNR model, as it focuses on treatment, still does not specify potential effects of deviant acts on subsequent problems in self-regulation. Yet, especially in childhood and adolescence, when personality (and by extension, underlying self-regulation) has not yet fully developed, certain behavioral problems might influence later personality until it solidifies (see Ge & Conger, 1999). Conceptually, it is generally recognized that significant life experiences shape the development of personality and underlying self-regulation strategies (Bleidorn, Hopwood, & Lucas, 2018; Denissen, van Aken, Penke, & Wood, 2013). We know there is

a relatively strong association between deviance and self-regulation from previous research (Vazsonyi *et al.*, 2017); however, the question remains whether the development of deviance can be explained by earlier levels of self-regulation and vice versa.

Longitudinal research investigating the reciprocal effects of self-regulation and deviance is largely lacking. Yet, some evidence for the possibility of reciprocal effects emerges from studies that have shown bidirectional effects between deviant behavior and personality, or temperament constructs that are related to self-regulation in childhood and adolescence. An early study (Ge & Conger, 1999) showed that delinquent behavior at age 12–16 years significantly predicted the slope of negative emotionality and low constraint at age 18 years. A study in children found that between the age of 30 and 54 months, earlier externalizing problems (defiance and aggression) predicted effortful control (*i.e.*, attention and inhibitory control) at later ages (Eisenberg, Taylor, Widaman, & Spinrad, 2015). Furthermore, deviance and substance use at age 19 years has been found to predict decision-making competence at age 30 years (Parker, Bruine de Bruin, Fischhoff, & Weller, 2018).

These studies highlight the possibility of bidirectional effects between self-regulation and deviance over time. Unfortunately, little research to date has investigated this question directly. In one study, Clinkinbeard, Barnum, and Rhodes (2018) found that delinquent youth, compared to a matched control group, were more likely to show poor self-control in adulthood, while controlling for prior self-control and other potential influences. Vazsonyi and Ksinan Jiskrova (2018) found bidirectional effects between self-control and deviance from age 4.5 years up to age 11.5 years, but that only deviance influenced self-control from age 11.5 years to age 15 years. However, another longitudinal study using a cross-lagged panel model with three waves of data, 6 and 12 months apart, showed that self-control influenced aggressive and delinquent behavior in adolescents, but not the other way around (de Kemp *et al.*, 2009). Although these effects of deviance on self-regulation were not hypothesized *a priori*, the authors of these studies have provided possible explanations for their findings. In particular, some of these explanations for the effects of deviance on self-regulation were based on methodological considerations (*e.g.*, due to construct overlap; Vazsonyi & Ksinan Jiskrova, 2018). Others proposed theoretical reasons as well. For instance, deviant youth who spend time on instantly gratifying activities and interacting with deviant peers, may spend less time developing their self-regulatory skills than their nondeviant peers (Clinkinbeard *et al.*, 2018). Furthermore, the label given to deviant youth by society, might lead to a self-fulfilling prophecy, in such a way that deviant youth do not or cannot put effort into developing their self-regulation because their surroundings treat them like a deviant individual (de Kemp *et al.*, 2009).

Though these studies shed light on the associations between self-regulation and delinquency, it remains unclear why there were mixed results for a reciprocal association between self-regulation and deviance. This heterogeneity in observed directionality effects might be dependent on the developmental age of the participants, on the time of follow-up (*e.g.*, months or years), or on different conceptualizations of self-regulation and deviance (*e.g.*, narrow-band definitions of each).

The directionality of effects might not be so simple, and earlier deviant behavior might in part contribute to an individual's self-regulation ability later in life. More evidence of bidirectionality (*i.e.*, both variables predicting each other over time) would also mean that existing theories must take into account these new

insights, to incorporate a more dynamic and reversible, rather than a one-way view. Evidence of this sort would align with more recent rehabilitation models of deviance, such as the RNR (Andrews & Bonta, 2010). Bidirectional effects between self-regulation and deviance would also be relevant for prevention and treatment programs. By relying only on traditional theories, they might focus too much on targeting self-regulation in an attempt to reduce future deviant behavior. In contrast, more evidence of bidirectional effects would suggest that prevention and treatment should focus more on these reciprocal influences within each individual and try to break potentially vicious cycles. This would mean that decreasing or preventing deviant behavior at younger ages through intervention, or focusing on the aftermaths of deviant behavior can have a long-term positive effect on an individual's self-regulation skills.

The current study aims to investigate potential bidirectional associations between self-regulation and deviance across adolescence and young adulthood. We first examined the longitudinal measurement invariance of an index of self-regulation from adolescence to adulthood. Then, two competing theoretical models were tested, one that specified only effects from self-regulation to deviance (unidirectional model, see Figure 1a) and the other with effects in both directions (bidirectional model, see Figure 1b). The current study opted for a within-persons approach rather than looking at mean-level change, as changes within an individual may have more relevant application in the field. This was accomplished by using a random intercept cross-lagged panel model over eight waves of data spanning over 20 years where the direction of effects could be tested across time adopting a person-centered approach.

Methods

Registration

The research questions and hypotheses for the current study were registered on the Open Science Framework (OSF). The initial registration was made before receiving the data, only based on codebook information (<https://osf.io/nd4uf>) and an update was made after receiving the data (<https://osf.io/brn9h>). There are still some differences with the current manuscript that were made to optimize data analysis; any such difference is mentioned in the relevant parts of the manuscript.

Longitudinal data

Longitudinal data from the Center for Education and Drug Abuse Research (University of Pittsburgh, CEDAR; <https://www.pitt.edu/~cedar/>) study were used for the current research. Data were collected around age 10–12, 14, 16, 19, 22, 24, 27, and 30 years, among 775 families. Data were collected from three groups: those with a substance-abusing parent, those with a parent without substance use but with a psychiatric disorder, and those with parents without substance use or psychiatric problems. In the current study, we were not interested in results related to substance use and no differences in results were expected based on group membership, therefore analyses were conducted on the whole group in order to broaden the diversity of the sample characteristics and increase variability in scores. In addition, group membership was not relevant because we only investigated within-person effects.² The project was approved by the Institutional Review Board of the University of Pittsburgh Medical Center.

Participants

For the current study, 772 out of 775 participants who completed measurements on both self-regulation and deviance at one or more points in time were included (from 740 at T1 to 287 at T8). A relatively small part of the sample was female (29.1%), the majority of participants was white (71.8%), and 20.6% was black. At the first testing time, the majority had finished 4th or 5th grade (56.9%), while 14.6% had only finished 2nd or 3rd grade and 22.7% had finished 6th or 7th grade. The majority of participants prescribed to some form of religion at the first measurement, mostly protestant (47.7%) and Roman Catholic (34.7%), with smaller percentages of other religious convictions (7.2%) and nonreligious participants (5.5%).

Measures

Self-regulation

The Abbreviated Dysregulation Inventory (ADI), a 30-item version of the full Dysregulation Inventory (Mezzich, Tarter, Giancola, & Kirisci, 2001), was used to measure deficits in self-regulation, with higher scores indicating poorer self-regulation.³ Participants reported on their self-regulation on a scale from zero (never true) to four (always true) at all eight time points. The ADI consists of three scales with 10 items each: an affective, a behavioral, and a cognitive scale. Confirmatory factor analysis (CFA) showed poor fit for the three-factor model at most time points (e.g., comparative fit index (CFI) < .668, using two parcels for each scale). The CFAs showed that the cognitive parcels did not load or loaded the weakest on a higher-order self-regulation factor. This might be because the cognitive items tended to be more future oriented (e.g., “I think about the future consequences of my actions”), whereas the items for the behavioral and affective scale were more oriented on the here and now (e.g., “I have trouble controlling my temper,” “Little things or distractions throw me off”). Several CFAs were done based on the modification indices and different models were tested with alternative scales based on expert-consensus approach on item content among the author team. The CFAs showed that a model without the cognitive component and with the behavioral component split into three (theory-based) components fits best (e.g., CFI < 0.937, only one under .95). Therefore, in the eventual model, the affective (e.g., “Often I am afraid I will lose control of my feelings”) and three behavioral scales—hyperactivity (e.g., “I cannot seem to stop moving”), inattention (e.g., “I am easily distracted”), and impulsivity (e.g., “I spend money without thinking about it first”), were used as indicators of the latent construct self-regulation. Within-person intraclass correlations (ICCs) for each scale at each time point were moderate to good (ICC = .70–.75). Cronbach alpha (see Mallery & George, 2003) for the affective ($\alpha = .85-.91$), hyperactive ($\alpha = .78-.85$) and inattentive ($\alpha = .78-.83$) scale was acceptable to good, whereas the internal consistency for the impulsive scale was rather poor ($\alpha = .48-.65$). When taking all items together, internal consistency of the total scale was excellent ($\alpha = .91-.92$).

²We hypothesized less stability of self-regulation in vulnerable groups, but were unable to check this due to model complexity.

³The original measure of self-regulation was a full-scale 92-item inventory, but after factor analyses and literature review on the measure it was decided to use an abbreviated version of the questionnaire due to superior psychometric performance.

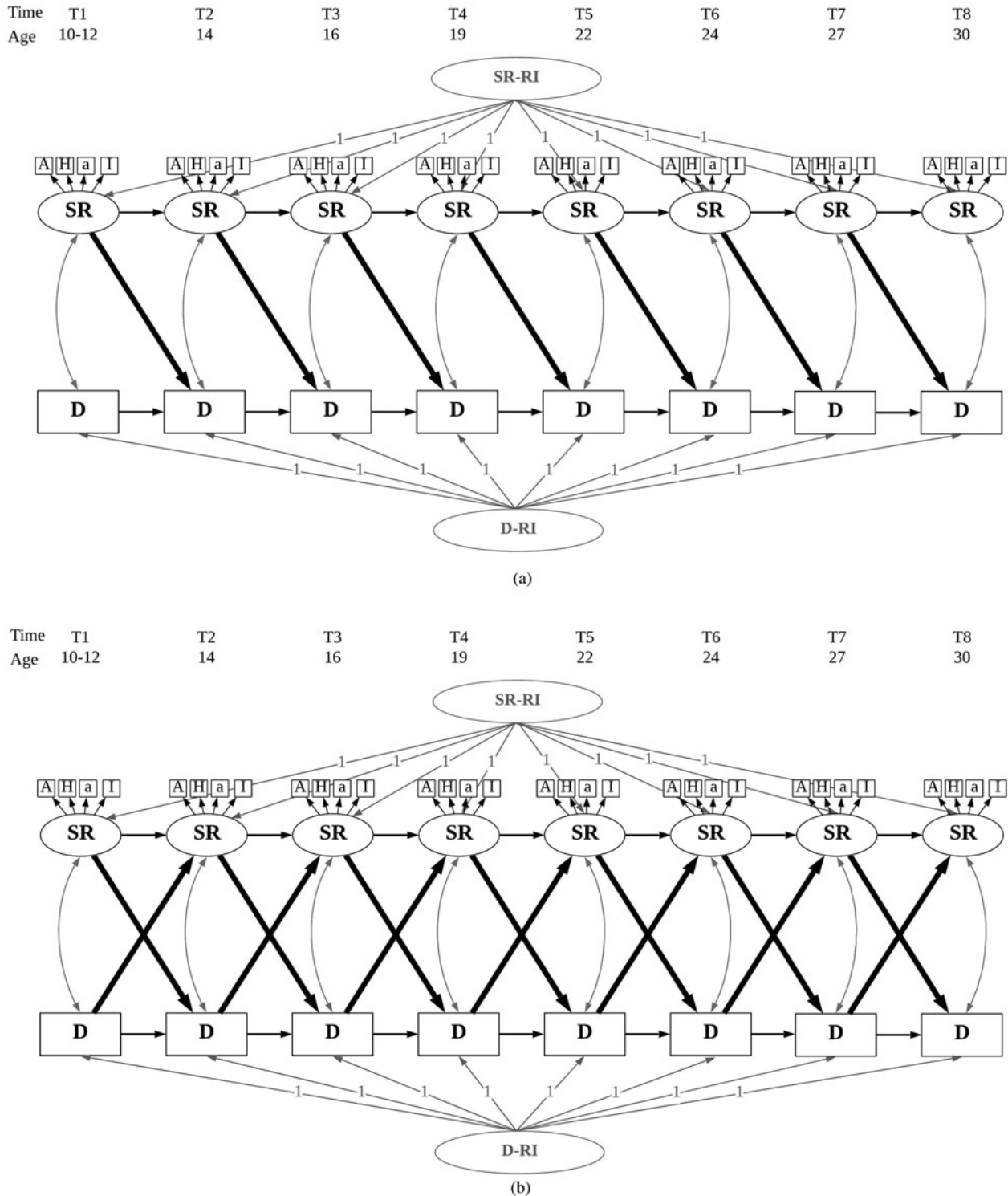


Figure 1. Conceptual models for the RI-CLMP, single-headed arrows represent regressions, double-headed arrows represent covariances. (a) Unidirectional model. (b) Bidirectional model. SR = self-regulation, D = deviance, RI = random intercept, A = affective, H = hyperactive, a = lack of attention, I = impulsivity.

Deviance

Parent reported deviance was measured at T1 and T2 using items from the Child Behavior Checklist (CBCL; Achenbach, 2009). Self-reported deviance was measured at all remaining time points using items from the youth self-report, young adult self-report, and adult self-report (Achenbach, 2009)—three slightly different questionnaires with similar content but with item-wording

adjusted to fit participants' developmental stage. Twelve items from the parent- and self-report were selected, these items were highly similar in content and wording; for example, “Destroys things belonging to his/her family or others” and “I damage or destroy things belonging to others”. Items represented both minor deviant behaviors (e.g., “I lie or cheat”) and more severe deviant behaviors (e.g., “I physically attack people”). Items were

scored on a scale from 0 (“not true”) to 2 (“very true or often true”) and sum scores for all 12 items were used to conduct the analyses. Data from teachers were available at T2 and T3, but were not used because of a low ICC (.28) and a relatively low correlation with both T2 parent report ($r = .34$) and T3 self-report ($r = .19$). Correlations between T2 parent- and T3 self-report were comparatively higher ($r = .42$), and the ICC of both the parent- (ICC = .76) and self-report (ICC = .65) were at least moderate. When combining parent- and self-report, the ICC was moderate (ICC = .67). Internal consistency for the scale at each time point was acceptable to good ($\alpha = .73-.84$).⁴

Missing data

Item-level missing data

There were little missing data on item-level. For the affective scale of self-regulation, there was only one participant with one missing item at Time 5 and one participant with three missing items at Time 6. For the behavioral scales, only one participant had a missing item at Time 6. For deviance, there was one item missing for between one and nine participants at any point in time, and one participant with three missing items at Time 2. Considering the low number of missing items for each scale, missing items were substituted by the individual's mean score on the scale in order to calculate the total score.

Longitudinally missing data

Considering the longitudinal set-up of the data, participant drop-out or inconsistent responding, observations are missing for participants to varying extents at each time point. In total, there were 3,166 observations of all self-regulation indicators and 4,150 observations of the deviance measure, spread across all eight time points. As observations for self-regulation measures were always equal, in this section, we speak of self-regulation rather than each of the indicators when discussing missingness. There were 3,120 overlapping observations for both variables (e.g., participant A at Time 3 had scores for both measures would equal one overlapping observation). There was on average 48.7% missing data for the self-regulation variable, with missingness varying from 26.6% (T4) to 62.8% (T8). For deviance, there was on average 32.8% missing data for the deviance measure, varying from 4.1% (T1) to 62.8% (T8).

As analyses were mainly aimed at looking at cross-lagged and auto-regressive effects, the number of overlapping observations over time were also investigated. Within self-regulation, there were on average 313.14 overlapping observations between consecutive time points, ranging from 238 (T7-T8) to 433 (T4-T5) observations. Within deviance, there were on average 435.86 overlapping observations between consecutive time points, ranging from 238 (T7-T8) to 587 (T2-T3). When looking at the overlap between self-regulation and deviance one time point later, there were on average 310.57 overlapping observations (range = 238–435). When looking at the overlap between deviance and self-regulation one time point later, there were on average 347.86 observations (range = 238–503).

Measurement invariance of the self-regulation measure

Three models for the measurement invariance of self-regulation with increasing constraints were run and compared using structural equation modeling (SEM) in the R-package Lavaan (Rosseel, 2012), namely configural, metric, and scalar (see van de Schoot, Lugtig, & Hox, 2012). These models contained only the self-regulation indicators and the latent construct. The configural model contains all the CFAs, but without any further constraints. The metric model constrains the factor loadings at each time point to be equal (e.g., the loading of the affective element is the same across time). The scalar model also constrains the intercepts at each time point and is considered as strong invariance. Chi-square difference tests were done to compare the models, a nonsignificant score means the models perform equally well and invariance holds at this particular level. Models are always compared to the closest established model. For the purpose of the current analyses, at least metric invariance needed to be achieved, as this means that the same meaning is attributed to the construct at each point in time (van de Schoot et al., 2012).

Random intercept cross-lagged panel model

To investigate the potential bidirectional effects between self-regulation and deviance, a Random Intercept Cross-Lagged Panel Model (RI-CLPM) was tested using SEM in Lavaan (Rosseel, 2012). This analysis is used to estimate the effects of two or more variables on one another over multiple time points. Adding a random intercept to the model ensures that intra-individual effects are tested rather than looking only at mean effects. This is achieved by extracting a constant from the variables of interest at each time point (see Figure 1). This approach allows a more reliable estimation of person-centered effects of one variable on another than the CLPM without a random intercept, as inter-individual differences are filtered out (Hamaker, Kuiper, & Grasman, 2015). A RI-CLPM was chosen over multilevel modeling, as we were more interested in the temporal associations between the two variables over time, rather than predicting individual changes over time.

In the tested models, self-regulation was operationalized as a latent construct defined by affective regulation, hyperactivity, inattention, and impulsivity (see section above about the measurement invariance of this measure). Deviance was operationalized and included as an observed variable. All models were run using the same settings in Lavaan's SEM function, such that missing data were handled using Full Information Maximum Likelihood estimation (FIML; Collins, Schafer, & Kam, 2001), a robust maximum likelihood estimator was used to estimate the models together with robust Huber–White standard errors and a Yuan–Bentler-like test statistic (see <http://lavaan.ugent.be/tutorial> for more information).

Several competing nested models were tested and compared to each other in order to identify the best-fitting model. First, a unidirectional model with effects of self-regulation on deviance was tested (Figure 1a), which was based on the General Theory of Crime (Gottfredson & Hirschi, 1990). Next, a bidirectional model specifying reciprocal associations over time between self-regulation and deviance (Figure 1b), based on resilience and desistance theories, was tested and compared to the unidirectional model. In all cases, autoregressive effects of both variables were estimated between all consecutive time points. Model fit was examined based on robust versions of the Comparative Fit

⁴The registration included a measure of psychopathology; we decided to exclude this element from the study, as there was too little variation for predicting other variables.

Table 1. Descriptives of deviance and estimated self-regulation for each time point.

Time	Deviance				Self-regulation			
	<i>N</i>	<i>M</i> (<i>SD</i>)	Min	Max	<i>N</i>	<i>M</i> (<i>SD</i>)	Min	Max
T1	740	1.53 (2.55)	0	20	772	0.00 (3.15)	−7.80	12.58
T2	587	1.95 (2.99)	0	21	772	0.60 (3.25)	−6.79	12.60
T3	625	2.91 (3.22)	0	18	772	0.56 (2.89)	−5.77	15.44
T4	563	2.29 (2.80)	0	19	772	0.55 (3.06)	−4.73	14.41
T5	480	1.97 (2.36)	0	12	772	0.55 (3.29)	−4.95	14.47
T6	503	1.79 (2.37)	0	18	772	−0.08 (3.07)	−5.31	17.93
T7	365	1.67 (2.18)	0	12	772	−0.14 (2.92)	−5.45	14.39
T8	287	1.62 (2.13)	0	10	772	−0.07 (2.73)	−4.84	15.00

Note: T = time point, self-regulation scores are based on a FIML estimation.

Index (CFI), Tucker–Lewis index (TLI), Root Mean Square Error of Approximation (RMSEA) as well as the Standardized Root Mean Square Residual (SRMR). A model was considered to have good fit if two or more of the indices met the criteria suggested by Hu and Bentler (1999); that is, CFI/TLI > .95, RMSEA < .05, and SRMR < .08. Nested models were compared using a χ^2 difference test, where a significant result means that the more complex model, with more freely estimated parameters (i.e., lower degrees of freedom) fits better.

Results

Descriptive statistics

Descriptive statistics of the observed deviance variable and the estimated descriptives of the latent self-regulation variable can be found in Table 1. As the descriptives of self-regulation are estimated, these are not limited to the extent of the scale (e.g., some are negative), but do still correspond to the directionality of the scale (higher scores mean greater dysregulation). Deviance scores ranged from 1.53 (T1) to 2.91 (T3) and dropped again to 1.62 (T8). Estimated self-regulation scores started at 0.00 (T1) went up to 0.60 (T2) and then dropped to −0.07 (T8).

Measurement invariance

For the latent variable self-regulation, measurement invariance of the four-scale CFA (as described in the methods section) was tested in Lavaan. A χ^2 test showed no significant differences between the configural and the metric model, $\chi^2(21) = 15.87$, $p = 0.78$, meaning the metric model performed as well as the configural one, and therefore metric invariance was established. A scalar invariance model was tested but found to be significantly worse than the metric model $\chi^2(21) = 56.48$, $p < .001$. As scalar invariance was not established, the models are conducted with the metric constraints only.

Comparing models

Different RI-CLPMs for the unidirectional and bidirectional model are described below. These models show the within-person associations between the variables over time. Fit indices for all

models as well as the χ^2 difference test results can be found in Table 2.

The original unidirectional model was one with random intercepts, a latent self-regulation construct, measured variances of and covariances between the self-regulation and deviance constructs. Autoregressive coefficients were estimated for each construct, as well as the regression coefficients from self-regulation to deviance one time point later. The model showed a modest fit to the data, but not a good fit as indicated by the fit indices (see Table 2). From the modification indices (MI), it appeared that the main reason for the lack of fit was a covariance between each indicator of self-regulation at consecutive time points (e.g., affective at T7 and T8, MI ≈ 122). In order to improve the fit of the overall model, a second unidirectional model with estimated covariances between self-regulation indices at consecutive time points was tested. The model showed a significant better fit compared to the original model (see Table 2). The MI indicated mainly residual covariances also over indicators removed one time point more (e.g., MI ≈ 66 for affective at T4 and T6). It was decided, however, not to make these adaptations as the MI were smaller and model complexity would increase, as well as because correlated residuals over nonconsecutive time points were deemed less conceptually justified than those over consecutive time points.

As the covariance between the indicators would remain the same in the bidirectional model, the original model was not tested in the bidirectional model. Instead, the model including the covariances between the indicators was used from the start. This also allowed for the comparison of this model with the unidirectional model including the covariances. A visual inspection of model fit indices revealed a consistent, albeit marginal improvement in the fit indices. Further, the bidirectional model showed a significant increase in fit according to the χ^2 difference test (see Table 2). According to the MI, model fit could again be improved by releasing constraints on residual covariations between indicators of self-regulation one time point further (e.g., MI ≈ 68 for affective T4 and T6). Considering the slight improvement in fit, despite the increase in model complexity, the bidirectional model was chosen for further inspection without additional modifications. A figure with the significant outcomes for the unidirectional model allowing for covariance, can be found in the online supplementary material, but will not be discussed further.

Table 2. Model fit indices and model comparison.

Model	df	CFI	TLI	RMSEA	SRMR	χ^2 difference
Unidirectional original	737	.816	.805	.055	.081	
Unidirectional covariance	709	.901	.891	.042	.077	626.38*
Bidirectional covariance	702	.904	.893	.041	.075	28.38*

Note. CFI = Comparative Fit Index, TLI = Tucker–Lewis index, RMSEA = Root Mean Square Error of Approximation, SRMR = Standardized Root Mean Square Residual.

* $p < .001$, the χ^2 difference test is always done with the nested model above.

Bidirectional model

Figure 2 shows the significant paths for the final bidirectional model. All covariances and regression coefficients shown in Figure 2 were significant. Figure 2 shows standardized regression coefficients (γ) for each of the regressions, and the estimated correlations are reported instead of the covariances for ease of interpretation. For the measurement part of the model—that is, the latent variable of self-regulation—estimates were equal across time points (metric invariance) at 1 for the affective component, .37 for the hyperactive component, .53 for the attention component and .36 for the impulsive component. Standardized loadings varied per time point, but were between .70 and .88 for all variables at all time points. Standardized regression coefficients for the covariances between indicators of self-regulation are not shown for ease of readability, but all lines shown in Figure 2 were significant (standardized regression coefficients or covariances can be obtained from the corresponding author upon request).

Autoregressions for self-regulation were all significant and reasonably consistent in weight over time ($\beta = 0.19$ –.38). Autoregressions for deviance were significant up to age 20 years (T5) and again between T7 and T8, but not between T5 and T7. Follow up analyses showed that this lack of significant autoregressive coefficients remained also in models that did not include self-regulation. The association from T1 to T2 was stronger than associations between the following time points ($\beta = .55$ and $\beta = .20$ to .25, respectively). As shown in Figure 2, deviance exerted significant, unidirectional effects on self-regulation during adolescence (T1–T4), whereas self-regulation exerted significant, unidirectional effects on deviance in adulthood (T5–T7).

Discussion

The present study aimed to explore possible bidirectional effects between self-regulation and deviance from adolescence into adulthood using a RI-CLPM. A unidirectional model based on early criminological theories (e.g., Gottfredson & Hirschi, 1990) that posited the univocal association between earlier self-regulation and later deviance showed adequate fit to the data. However, our results showed that there is a complex and reciprocal association between self-regulation and deviance over time, more so than thought over the past three decades. Indeed, a bidirectional model showed a significant improvement in model fit compared to a model where only self-regulation was allowed to predict deviance. This suggests that deviance and self-regulation influence each other over time, rather than the association going only in one direction. In this bidirectional model, we found consistent autoregressive effects of self-regulation over adolescence and young adulthood, corroborating the conceptualization of self-regulation as relatively stable over time. However, deviance

predicted self-regulation during adolescence (T1–T4), but not the other way around. Self-regulation did not predict deviance until adulthood (from age 22 years until age 27 years), and only did so across two waves of time (T5–T7). This may be an indication that self-regulation is not the main driving force behind deviance, at least during adolescence.

For deviance, there was a markedly stronger autoregression between Time 1 and Time 2, possibly due to measurement similarities (both being parent reported deviance). The autoregressive effect for deviance was only significant at times when self-regulation had no influence on deviance, and was not significant between time points where self-regulation predicted later deviance. This lack of autoregression remained in the model which included only deviance, meaning that we cannot explain this effect by self-regulation absorbing the variance that would otherwise be explained by deviance itself. Although results vary and most research indicates relative stability of deviant behaviors, some studies also show instability (see Piquero, Carriaga, Diamond, Kazemian, & Farrington, 2012) or find some individuals with adult-onset antisocial behaviors (e.g., Mata & van Dulmen, 2012). Therefore, it may be that it is not simply self-regulation but a combination of self-regulation and other factors (e.g., social control or social bonds; Longshore, Chang, Hsieh, & Messina, 2004), which are not included in the model that may explain the variation in deviance. The same eight items for deviance not carrying the same meaning in adolescence and adulthood, may also cause the lack of autoregressive effects. For example, it may be speculated that being mean to others or lying and cheating may be relatively common and normative behavior in adolescence, while it is not in adulthood. Although considering the timing of the lack of autoregressive effects (age 22–27 years), one would expect the meaning of the statements to be quite similar, as this is considered the same developmental period (i.e., young adulthood).

Although past research has shown that self-regulation is often correlated with deviant behavior (see Vazsonyi et al., 2017), the current study found no evidence for a strictly unidirectional causal association from self-regulation to deviance in adolescence. Contrary to the assumptions of classical criminological theories, our results showed that deviance is also a predictor of self-regulation. This bidirectional association may occur because, during adolescence, self-regulation is still not fully developed and can still be determined by behaviors. This is in line with other research showing an effect of deviance on self-regulation in adolescence (Clinkinbeard et al., 2018; Vazsonyi & Ksian Jiskrova, 2018). The current study extends this research by following the development of these associations into adulthood, and found that in adulthood, the directionality of the effect changes. One possible reason for this change might be dependent on maturation and stabilization of self-regulatory processes, meaning that previous behavior no longer has a significant effect. However, it

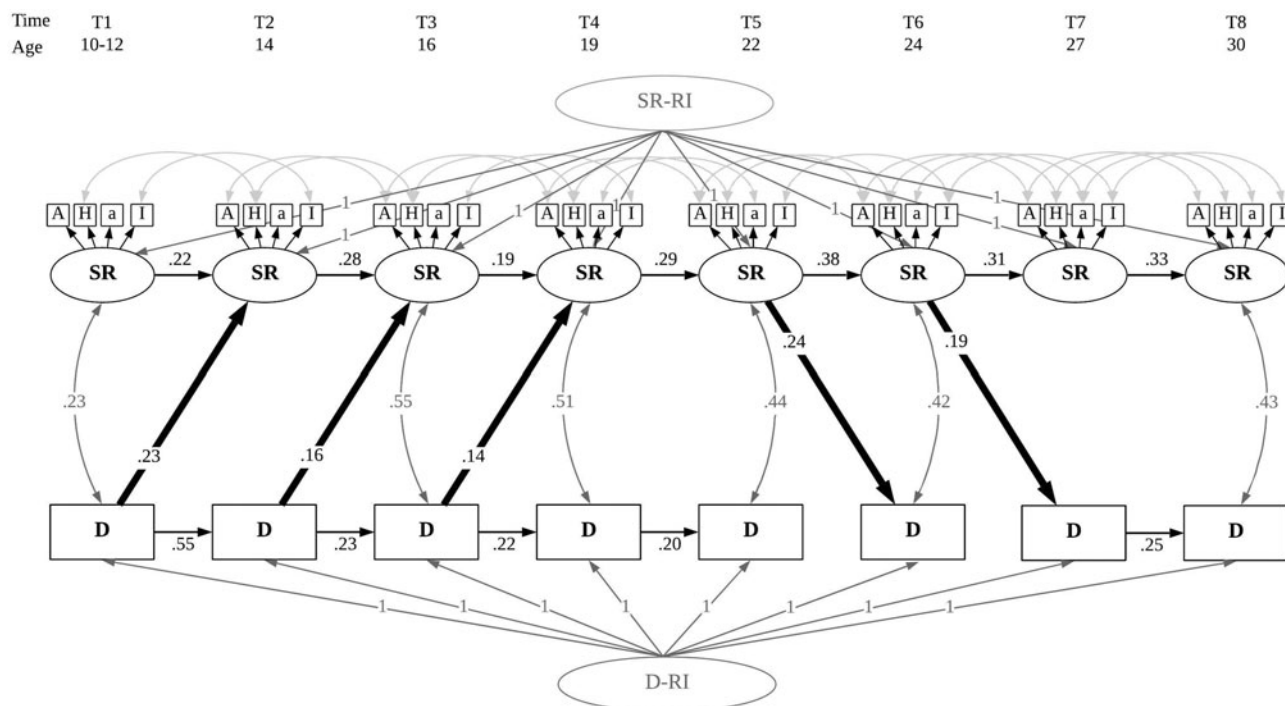


Figure 2. Outcome model for the bidirectional RI-CLMP, single-headed arrows represent regressions (connoted with standard estimates similar to β -coefficients), double-headed arrows represent covariances (connoted with estimated correlation coefficient). All arrows shown represent associations significant at the .05 level. Nonsignificant associations and covariance between latent indicators are not represented in this figure for clarity. SR = self-regulation, D = deviance, RI = random intercept, A = affective, H = hyperactive, a = lack of attention, I = impulsivity.

might also be dependent on constructs not measured in the current study such as social control, changing environments and peer relations. Considering the change occurs at an age where youth might get employment, this change in role might also contribute to the observed shift in directionality.

The influence of self-regulation on deviance posited by traditional theories, that is, a limited ability to control emotions, thoughts and behavior that leads to deviant behavior or criminal activity (e.g., Agnew, 1992; Gottfredson & Hirschi, 1990), may be a more accurate representation of what happens in adults, when deviant conduct has already been present for a longer time. Rather, the same application to developmental models of deviance may need revision to accommodate evidence that occurrence of deviant behavior may contribute to problems with self-regulation in adolescence, and only at a later age this influence reverses. The lack of influence of either self-regulation or deviance at the last time point may be due to more methodological reasons, as the last time point had the largest percentage of missing data and the least overlap with the previous time point compared to other times. A significant covariation of self-regulation and deviance was still found at this time, indicating that despite a lack of a direct causal link, there is still a clear association between the two variables.

Although this is a first step, we believe that the current results may eventually bear implications for both theory and clinical practice. On a theoretical level, a bidirectional association shows that self-regulation is still subject to external influences well into adolescence, and that a factor that contributes to self-regulation in adults can be a deviance at younger age. This is not something that is represented in the current theoretical views. Although most theories leave open the possibility that self-regulation may be influenced by external factors in adolescence (Agnew et al.,

2002; Andrews & Bonta, 2010; DeLisi & Vaughn, 2014; Moffitt et al., 2011), traditional theories view self-regulation or self-control as more stable and less likely to be influenced (e.g., Gottfredson & Hirschi, 1990). In addition, among those theories that indicate flexibility in the construct, not all are specific on the age when this may still happen, on the factors involved or on the extent to which interventions might have effect. Because of a lack of prior theorizing regarding this directional effect, it is difficult to say to what extent the results of this study can be compatible with these theories. However, if one interprets deviant behavior as a form of strain in Agnew's general strain theory (Agnew et al., 2002), such strain could then, according to this theory, influence constraint. Furthermore, when looking at the views of Moffitt et al. (2011), they imply that stopping adolescent "mistakes" might have a positive influence on long-term outcomes that are also dependent on self-control. It might just be that self-control in that case functions as a mediator between those adolescent mistakes and adult outcomes. Looking from a broader perspective, the current findings could be seen in light of genotype-environment interaction (Scarr, 1992). That is, individuals that show deviant behavior (as part of their gene expression) can choose environments that in turn influence and enhance their phenotype (i.e., characteristics or traits). In this case, this specifically concerns environments that interfere with practicing and strengthening self-regulation skills. This might be one way to explain the bidirectional effects found in the current study, although this cannot be tested at present.

When it comes to practical implications, it seems that especially during adolescence, rather than only trying to reduce deviance by improving self-regulation, it would be good to intervene on the behavioral level too, as well as on the consequences of engaging in deviant behavior, in order to prevent a deterioration

of self-regulation. That is, working on the aftermaths of the occurrence of deviant behavior may lead to less problems in self-regulation, which in turn may lead to a reduction in deviance in young adulthood. It could be that receiving the label of deviant youth affects their future effort to self-regulate (through a self-fulfilling prophecy; see Bernburg, Krohn, & Rivera, 2006). Therefore efforts to reduce stigma might also have positive effects on self-regulation. This is in agreement with the ideas of de Kemp et al. (2009) as well as Sherman's (1993) ideas on defiance and punishment. Reducing the occurrence of deviant behavior and stigmatization in adolescence may stimulate engagement in more positive, long-term goal-oriented behavior, and might take youth away from deviant influences, having a positive effect on self-regulation and the outcomes that follow. In contrast, not only deviance per se, but also the subsequent sanctions may contribute to a negative spiral that undermines self-regulation skills later in time.

The current study had some limitations that should be taken into account when interpreting the results. First, the sample was mostly male and mostly white, thus generalizability to more diverse samples warrants caution. That is, the development of the deviance—self-regulation associations might be different depending on gender and race, as the circumstances surrounding these groups might differ. Second, the sample consisted for a large part of individuals with at least one parent who had a diagnosed substance use disorder at the beginning of the study. Due to the nature and the complexity of the model, we chose to not consider this variable in these analyses. Other demographic variables such as education and socioeconomic status were also not used as control variables due to the model complexity. Unfortunately, the data collection for the current sample started at age 10 years, and we are not able to say anything about the associations between self-regulation and deviance at earlier ages, although we know these may differ to some extent (e.g., Vazsonyi et al., 2018).

From a statistical perspective, we acknowledge several limitations. For instance, there were reasonable amounts of missing data that had to be estimated in the model, which despite the robustness of the full information approach may lead to unaccounted bias. In addition, the model fit, especially for CFI and TLI, was not as good as it should be in order to indicate a good fit, although the other fit measures were in the acceptable range. It is likely that model fit could have been improved if covariation of the latent indicators for self-regulation would have been allowed over two time points instead of only one, though we did not do this in favor of a more straightforward approach. Moreover, the measure of self-regulation did not fit its originally intended structure and therefore our measure consisted of our own factor-analyzed variant, this is another potential limitation, which may result in differences between the current results and studies that use different self-regulation measures.

Taken together, our results imply that future research investigating the association between self-regulation and deviance should be cautious when reporting associations as causal relationships, as has often been done. Further, we highly recommend more longitudinal research with repeated measures of both constructs take place. Ideally, this research would start measuring self-regulation and deviance before the age of 10 years, and employ multiple validated measures of both self-regulation and deviance. Moreover, we feel that future research should attempt to investigate more clearly the effects of adolescent interventions designed to reduce youth delinquency. Ideally, this research would

take into account, not only self-regulation, but also different potential influences, such as deviant peer influences and labeling of deviant youth (e.g., Bernburg et al., 2006; Boman, & Mowen, 2019). If early interventions can help youth (temporarily) desist from deviant behavior, or minimize the consequences of this deviant behavior, future self-regulation might be better compared to those where no intervention takes place, leading to less deviant behavior in adulthood.

In summary, the current study significantly extends the knowledge base from the limited recent research on potential bidirectional effects between self-regulation and deviance (Clinkinbeard et al., 2018; Vazsonyi & Ksinan Jiskrova, 2018). Although most traditional theories often focus on unidirectional explanations of self-regulation on deviant behavior, our study suggests that this assumption may be too simplistic. Instead, we showed that during adolescence, deviance tends to influence self-regulation, whereas in young adulthood self-regulation influences deviance. The results should, of course, not be seen as definitive proof for a bidirectional association between the two variables; however, they do provide fodder for debate, which may, in turn, lead to the re-evaluation of the core pillars of current theories and research practices. Therefore, we suggest that future research should assess both constructs at multiple time points over a longer time span, rather than viewing deviant behavior only as an outcome or only investigating effects in one direction. We believe the current research fits within a broader framework, showing that character traits can be affected by behaviors that are likely to shape one's environment, even in adolescence.

Supplementary Material. The supplementary material for this article can be found at <https://doi.org/10.1017/S0954579420000656>.

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